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Alternative Methods in Learning Chemistry: Learning with Animation, Simulation, Video and Multimedia

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SYNOPSIS

INTRODUCTION

Occurring on a molecular level in many chemical phenomena makes learning chemistry difficult (Ben-Zvi, Eylon & Silberstein, 1987; Gabel, Samuel & Hunn, 1987). This is because an understanding of chemistry is based on assigning meaning to the unseen and the intangible (Kozma & Russell, 1997). In recent years, benefit has been derived from information and communication technologies (ICT) in attempting to overcome the difficulties encountered in the conceptual learning of chemistry (Hakerem, Dobrynina & Shore, 1993; Hameed, Hackling & Garnett, 1993; Russell & Kozma, 1994; Williamson & Abraham, 1995; Russell et al., 1997; Burke, Greenbowe & Windschitl, 1998; Sanger, Phelps & Fienhold, 2000; Ebenezer, 2001; Laroche, Wulfsberg & Young, 2003; Stieff & Wilensky, 2003; Yang, Andre, Greenbowe & Tibell, 2003; Ardac & Akaygun, 2004; Marcano, Williamson, Ashkenazi, Tasker & Williamson, 2004; Zahn, Barquero & Schwan, 2004; Kıyıcı & Yumuşak, 2005; Lee, Plass & Homer, 2006; Kelly & Jones, 2007; Michel, Roebers & Schneider, 2007; Winberg & Berg, 2007; Abdullah & Shariff, 2008; Daşdemir, Doymuş, Şimşek & Karaçöp, 2008). Alternative learning methods such as animation, simulation, video, multimedia and other similar technological tools have become more important in chemistry education. Therefore, the main argument of this study is to focus on those alternative learning methods in chemistry education.

PURPOSE OF THE STUDY

The main purpose of this study is to review the research articles related to effects of technological tools (animation, simulation, video, multimedia) on learning chemistry. This compilation is significant in terms of both setting forth the benefits technological tools can provide students and also as a source of information on Internet-based learning opportunities. The present study also gives information on cognitive load theory (Sweller, 1988; Chandler &

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Sweller, 1991; Baddeley, 1992) which may be useful to researchers in examining the effects of technological tools on learning.

DISCUSSION and RECOMMENDATIONS

Many students in secondary school and in the universities have many difficulties in understanding chemistry (Ross & Munby, 1991; Griffiths & Preston, 1992; Nakhleh, 1992; Schmidt, 1995; Sanger & Greenbowe, 1997; Stavridou & Solomonidou, 1998; Pınarbaşı & Canpolat, 2003; Sepet, Yılmaz & Morgil, 2004; Agung & Schwartz, 2007; Othman, Treagust & Chandrasegaran, 2008). For this reason, students develop scientifically unacceptable conceptions about many subjects or concepts in chemistry. Their knowledge of chemistry is therefore incomplete and incoherent (Kozma & Russell, 1997). Many students, in fact, merely memorize chemistry concepts without actually learning them (Haidar, 1997; Niaz & Rodriguez, 2000). This situation is an indication of why some students never come to like chemistry.

Conceptual understanding in chemistry is related to the ability to explain chemical phenomena through the use of *macroscopic*, *molecular* and *symbolic* levels of representation (Gabel, Samuel & Hunn, 1987; Johnstone, 1993; Gabel & Bunce, 1994; Wu, Krajcik & Soloway, 2001). It is known that when relationships are formed between these three levels of representation, students understand and learn more in chemistry (Sanger, Phelps & Fienhold, 2000). In learning environments that include ICT, students are able to form successful relationships between the three levels of representation in chemistry (Marcano et al., 2004) and thus learn the subject in a more effective and meaningfully (Nakhleh & Mitchell, 1993; Paselk, 1994).

Individuals construct mental models to interpret phenomena and make sense of them (Johnson-Laird, 1983). A mental model is defined as an individual's personal description of a concept or event that has been impressed in that person's mind (Coll & Treagust, 2003). Through ICT, students rearrange their thoughts about chemical phenomena and processes and build meaningful mental models (Clark & Jorde, 2004). ICT provide students the opportunity of improving their conceptual understanding and forming mental models of high quality (Lowe, 2003; Marcano et al., 2004).

Designs of constructivist learning environments that encompassed ICT for teaching chemistry were seen in the 1980's. In those years, ICT were used to teach high school chemistry students the subject of titration (Stevens, Zech & Katkanant, 1988). With the use of these technologies within the educational environments, the mode of education switched from teacher-centered learning to student-centered learning. In student-centered learning, instead of remaining passive, students actively participate in the learning process (problem-solving, building of knowledge, etc.) (Bernauer, 1995; Own & Wong, 2000). The role of ICT in student-centered education is to provide tools whereby the student's comprehension ability can be increased (Mayer, 2003).

It is known that the collaborative learning method benefits students in their learning process (Lonning, 1993). The use of ICT in teaching environments provides students with the opportunity for group work. The students can then communicate with each other to discuss the chemical phenomena and explain the chemical concepts (Basili & Sanford, 1991) that have been presented to them in the learning environment with technological tools (animation, simulation, videos, etc.) (Laroche, Wulfsberg & Young, 2003). This gives students the chance to exchange information and build a body of common knowledge (Solomon, 1987; Driver, Asoko, Leach, Mortimer & Scott, 1994).

Using ICT in teaching and learning is of the greatest importance. Teachers however may think that these technologies will be taking over their teaching responsibilities (Sutherland, 2004). Teachers must be well informed so that they do not harbour such beliefs.

Teachers should be provided with scientific explanations as to what the teacher's responsibility is and should be, within the framework of constructivist teaching that encompasses ICT. Furthermore, it will also be very important to enhance teachers' knowledge about how exactly to benefit from technological tools in the teaching environment. Teacher education should not only include technical information as to how to use the technology but should also cover how to choose the right methods and strategies to be used in the teaching environment where technological tools are employed. Teachers should be informed about the benefits technological tools can offer students when used in the classroom. For example, some chemical reactions may constitute a serious risk for students if carried out on their own. Instead of having students work on such reactions, possible risks might be avoided by using ICT to demonstrate.

The biggest problem encountered in the use of ICT in the classroom is the failure of teachers to effectively integrate these technologies with teaching and learning processes (Demiraslan & Usluel, 2005; Usun, 2006; Gülbahar, 2008). Teachers should be provided with in-service education on ICT integration. These in-service training sessions offered to teachers should be based on a "*learning through doing*" model and should be conducted by competent authorities. Teachers should be provided with an environment that will be conducive to learning more about making use of multimedia, simulation and animation software. Concrete examples should be presented to teachers in in-service training sessions. The effective and productive use of ICT in the classroom as well as the important role these technologies play in teaching and learning should be impressed upon teachers. Teachers should be consulted in the planning of in-service training programs and they should also be provided with opportunities for continuous education (Akpınar, 2003; Demiraslan & Usluel, 2005; Altun, 2007). Teachers should use ICT in the classroom environment for the purpose of supporting and improving their teaching (Sarıçayır, Şahin & Üce, 2006; Arnold, Padilla & Tunhikorn, 2009). The Ministry of National Education and school administrators should encourage teachers to use such technologies in the classroom environment.

Advances in technology and science have drawn attention to technological tools that appeal to the sense organs and require interaction with the learner in educational environments (Akkoyunlu & Yılmaz, 2005). Inevitably today, learning environments will from hereon be designed to make use of technological tools. Such educational tools should be designed to serve pedagogical purposes. Designs must consider both a student's prior knowledge and the development of knowledge over the course of the student's learning process. Moreover, the design of technological tools should consider the advantages that will be made available to curriculum as well as respond to the needs of students. That is, if a teacher is to benefit from a technological tool (animation, simulation or video) in the transfer of knowledge, the information provided by means of that technological tool must be appropriate to the student's level of knowledge. Another matter to be considered in the design of technological tools is cognitive load. The concept of cognitive load is defined as the mental cost of what is necessary to achieve activity in an individual's cognitive system (Sweller, 1988). Technological tools should be designed so as not to create an extreme load for the student's cognitive system. Memorization is influenced by extreme cognitive loads (Winberg & Berg, 2007).

CONCLUSION

Chemistry teachers must make much effort to create an ideal environment for teaching and learning. Including technological tools in the classroom will require teachers to employ different teaching techniques. Instead of making use of technological tools for a short-term educational program, however, students will benefit more from a longer period of learning. Designers of chemistry curriculum as well as chemistry teachers should take care to plan and

implement activities that include technological tools in accordance with pedagogical objectives since the structure of such activities will be meaningfully effective in a student's learning process. Furthermore, researchers in chemistry education may benefit from dual coding theory (Paivio, 1971, 1986; Clark & Paivio, 1991) and cognitive load theory (Sweller, 1988; Chandler & Sweller, 1991; Baddeley, 1992) through studies on the influence of ICT on learning. Although these theories are familiar to researchers in cognitive psychology, they are not adequately known in chemistry education. Recently, it has been observed that studies on the effects of technological tools on learning and teaching have begun to make use of the two theories. Dual coding theory and cognitive load theory may constitute new fields of study for researchers in chemistry education.

In conclusion, information and communication technologies present significant opportunities in the near future for the chemistry education programs. They may also be a beneficial and effective tool in the development of new methods and techniques.

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